TRANSIMS TRAVELOGUE

January 1995

TRANSIMS TRAVELOGUE describes current activities within the TRANSIMS project.

(LAUR-95-1240)

WHAT IS TRANSIMS?

The TRansportation ANalysis and SIMulation System (TRANSIMS) is one part of the multi-track Travel Model Improvement Program sponsored by the U.S. Department of Transportation and the Environmental Protection Agency. The TRANSIMS project has been identified as a major effort to develop new, integrated transportation and air quality forecasting procedures necessary to satisfy the Intermodal Surface Transportation Efficiency Act and the Clean Air Act and its amendments.

TRANSIMS is a set of integrated analytical and simulation models and supporting data bases whose development is being led by the Los Alamos National Laboratory. The TRANSIMS methods deal with individual behavioral units and proceed through several steps to estimate travel. TRANSIMS predicts trips for individual households, residents and vehicles rather than for zonal aggregations of households. TRANSIMS also predicts the movement of individual loads of freight. A regional microsimulation executes the generated trips on the transportation network to predict the performance of individual vehicles and the transportation system. Motor vehicle emissions are estimated using traffic information produced by TRANSIMS. A major advantage of TRANSIMS for air quality analysis is the detail it provides regarding motor vehicle operation.

Previously microsimulation at the detail performed by TRANSIMS required very fast, high capacity computers. The TRANSIMS team has investigated computational techniques to overcome such limitations and has demonstrated significant performance gains through distributed computing and other methods. Furthermore, it is expected, that by the time TRANSIMS has been completed, technical capabilities will have advanced sufficiently for greater computing capacity to be more readily available.

REQUIREMENTS ANALYSIS

After researching the Clean Air Act Amendments of 1990 and the Intermodal Surface Transportation Efficiency Act of 1991, we wrote a high-level issues and requirements document entitled "TRANSIMS Model Requirements as Derived from Federal Legislation." This document translates the analytical requirements stipulated in these recent federal legislations into high-level TRANSIMS design requirements. The key representational requirements were identified as: entity-level representations of individual travelers and freight items; databases and simulations that support the representation of sophisticated behavior and choice/utility models sensitive to travel time constraints, preferences, travel behavior, cost, and perceived quality of service; travel and environmental models, and system simulations. Furthermore, component models should be sensitive to detailed representations of environmental and vehicle characteristics correlated to both the geographic and demographic distribution of travelers; and simulation of continuous traffic, transit, freight, bike, and pedestrian travel over the course of extended periods (incorporating both peak and non-peak travel requirements), different days of the week, months, and seasons.

We have begun to identify requirements that pertain to the software and hardware environments in which the computer code will be implemented. As these processes proceed, we are working on an overall plan for systematic identification of the requirements that come from many sources.

TRANSIMS OPERATIONAL DESCRIPTION

We drafted the highest level TRANSIMS software document entitled "TRANSIMS: Operational Description of the Software Framework." This document sets the context for the selection of the application projects from which to derive detailed software functional requirements, the associated software specification documents, and the detailed design documents for components of the TRANSIMS environment. It presents examples of analyses that will be supported by TRANSIMS, describes the conceptual foundation and analytical rationale, and describes the major high-level components of the TRANSIMS architecture. The major components are: the Household and Commercial Activity Disaggregation Module, the Intermodal Route Planner, the Traffic Microsimulation, and the Environmental Simulation.

These components are supported by a Land Use and Demographic Representation and a Transportation Network Representation. Interfaces also must be provided for a Land Use and Demographic Forecast capability and a Transportation Infrastructure Change capability, both outside the scope of the TRANSIMS effort. Finally, an Analyst Toolbox supports the user in problem and analysis design, statistical analysis, sensitivity analysis, and visual presentation of the results.

HIGH-SPEED MICROSIMULATION

We have examined techniques to overcome the computational difficulties of calculating the second-by-second travel behavior of each model traveler throughout the day. Methods for attacking this problem include: higher performance computers, distributed processing, critical complexity, hybrid simulation, and fast algorithms.

When and where possible, we have considered computational algorithms for highly parallel processor computers. Because most TRANSIMS users do not have access to such capabilities, we have successfully developed methods for partitioning the microsimulation computational workload among the distributed processors of a local area network and even more broadly on worldwide networks. Furthermore, we have improved the performance by incorporating load balancing that shifts the effort when one or more processors are over- or under-utilized.

Critical complexity, an overriding concern throughout the TRANSIMS development, is determining that model detail, and no more, necessary to produce the emergent behavior that we are studying. Our work thus far is exemplified by the characteristic traffic dynamics behavior shown to emerge from very simple cellular automata models for vehicular traffic. Cellular automata traffic models divide the transportation network into a finite number of cells. For example, each cell could be approximately the length of a vehicle. Then at each time step each vehicle is moved from one cell to another according to a simple rule set.

In a hybrid simulation the simulation detail changes between regions. Thus, we may model most of a metropolitan area with the fast running cellular automata model that interfaces with a much more detailed analysis of a specific corridor or locale. A major difficulty we are addressing in hybrid simulations is matching the detailed simulation requirements with the leanness of the fast-running simulation.

An example of fast algorithms that we have examined is replacing rule-based driver behavior algorithms with trained neural networks that rapidly compute a driver's next action.

TRANSIMS PROGRAM PLAN CHANGES

After visiting six metropolitan planning organizations (MPOs) (Dallas-Ft. Worth, Boston, Portland OR, Oakland, Chicago, and Denver) and observing firsthand the differences in analytic procedures and needs, we determined that our initial approach of using two major applications to drive TRANSIMS development would not provide timely interaction and feedback from the TRANSIMS user community. Therefore, we have altered our plans. We intend to pursue the same end result, but with more interim products, capabilities, and applications.

Our new approach is to develop an interim operational capability (IOC) for each major TRANSIMS component presented previously in the TRANSIMS Operational Description section. When the IOC is ready, we will complete a specific case study to confirm the IOC features, applicability, and readiness. We will complete the specific case study with the collaboration of the staff of a selected MPO. This approach should give us quicker feedback from the user community.

The Traffic Microsimulation will be the first IOC, with the goal of having it ready for testing in August 1995. As this IOC is developed, we will work with a selected MPO to identify studies that the IOC should support. The second IOC will integrate the air quality analysis capability of TRANSIMS with the microsimulation. Again, the IOC development will be driven by studies identified as important to the users and will be followed by a specific case study. We intend to issue subsequent IOCs for the Intermodal Route Planner and for the Household and Commercial Activity Disaggregation modules. These IOCs may be standalone modules, but will be capable of integration with the other TRANSIMS modules. The case studies will demonstrate the integrated package.

This change in approach does not alter our goal of an integrated framework for predicting individual travel behavior and for supporting transportation planners from travel demand forecasting to assessments of transportation system modifications.

FIRST IOC: MICROSIMULATION

We have developed several microsimulation versions that successfully modeled traffic behavior. In the Albuquerque Demonstration, we simulated traffic on two interstates and at their intersection using vehicle objects on a continuous road network. For the IVHS Incident Detection Testbed, we

extended this capability to include many lanes, signalized intersections, incidents, and additional driver behavior. Our single-lane cellular automata (CA) simulation exhibited traffic congestion, shock waves, and roadway capacity. An enhanced CA version runs on distributed processers and dynamically redistributes the computational load during execution. Another CA version with multiple lanes and freeway interchanges simulated critical traffic volumes on the 48,000 km of the entire German Autobahn using a 64-node partition of the Intel Paragon parallel processor machine. This broad micro-simulation experience places us in an excellent position to take the best of what we have learned to develop the first Traffic Microsimulation IOC.

To the extent possible the first Traffic Microsimulation IOC will rely on data currently existing at MPOs. We will develop techniques to incorporate these data readily into the TRANSIMS methodology. The IOC will be supported with the capability to let the user adjust the input as necessary for his analyses. Similarly the user will be supported with several output options to support his analyses. We will develop these features with input and feedback from the potential users.

NCTCOG: FIRST CASE STUDY REGION

We presented the overall TRANSIMS approach to the six MPOs and obtained information on their responsibilities, transportation and air quality issues, processes for carrying out their activities, potential applications for TRANSIMS, their resources, and user feedback on what TRANSIMS should do for them. We are using this and other information to develop detailed requirements and specifications for the TRANSIMS architecture and design.

When we changed the TRANSIMS approach, we had sufficient information from these MPOs to decide which regional area to use for our first case study. We considered numerous factors, but the major ones were: staff and management interest, staff capabilities, and data availability. The ratings were very close and the decision was difficult, but we decided to work with the North Central Texas Council of Governments (NCTCOG) (Dallas-Fort Worth) for the first case study using the Traffic Microsimulation IOC. NCTCOG has enthusiastically supported this decision.

The input, feedback, and interest of all the MPOs we visited have been very helpful in establishing the scope and requirements for TRANSIMS. We anticipate that the future IOCs will be developed in association with case studies for other metropolitan regions. We also anticipate that there may be other supporting developmental efforts in which collaboration with a metropolitan region would be helpful both to the TRANSIMS effort and the MPO.

ENVIRONMENTAL MODELING

We have devoted our air quality efforts to five major tasks: the study and improvement of the current vehicle emissions models; the study of the current dispersion models for vehicle air pollution sources; the integration of our current suite of meteorological and air pollution dispersion models with the TRANSIMS Traffic model, the emissions model, and possibly a microscale air flow model; the preparation of a summary of literature relevant to air pollution modeling of vehicle sources; and the preparation of a TRANSIMS Environmental Modeling briefing.

To model air pollution concentrations successfully, TRANSIMS traffic output parameters (e.g., vehicle acceleration, speed, engine temperature) must be correlated to vehicle emission rates. We have collected numerous articles on the current USEPA emissions model (Mobile 5), vehicle emissions experiments, and vehicle driving cycle studies. We have contacted various experts on vehicle emissions (e.g., John German of the Environmental Protection Agency, Pablo Cicero-Fernandez of the California Air Resources Board). We have summarized some studies in a review document. We have defined a protocol for implementing improvements to the current emissions model.

In the process of investigating on-going U.S. work on calculating real-time emissions for vehicles, we obtained (1) data from the more relevant California Air Resources Board measurements of real-time emissions from vehicles operating under realistic high engine speed and load conditions; (2) a report on a South Coast Air Quality Management District project at UC Riverside to develop a program for obtaining traffic flow patterns, describing driving behavior, and estimating vehicle emissions; (3) a copy and a user's manual of a Radian Corporation program to calculate automobile evaporative emissions; (4) a Radian paper describing a method to calculate cold start emissions; and (5) a number of other driving behavior studies for specific conditions, such as freeway on-ramps and in different cities. We have explored the possibility of Los Alamos involvement in the National Cooperative Highway Research Program's three-year study of real-time vehicle emissions. We have an agreement in principle with Sierra Research Institute, who have studied driving behavior in California, to obtain their code to calculate real-time light-duty vehicle emissions and use it as a preliminary vehicle emissions module of TRANSIMS. To obtain a thorough understanding of

current vehicle air pollution issues, we have produced a summary paper of articles that we have read concerning highway and urban-canyon models and measurements, emissions measurements, and driving cycle experiments. As a first cut, we will use current vehicle emissions studies to correct the Mobile emissions model for high accelerations, cold engine starts, etc. Currently, several research groups (e.g., USEPA, CARB, SAI, GM, Ford, Georgia Tech) are actively engaged in experimental research in this area. We intend to improve our formulations as results become available. Note that the driving cycle will be obtained directly from the TRANSIMS traffic model.

FURTHER INFORMATION

For further information about the TRANSIMS program, please contact:

Dr. LaRon L. Smith
Los Alamos National Laboratory
Mail Stop F606
PO Box 1663
Los Alamos, New Mexico 87545

Phone: 505-665-1286
Fax: 505-665-5249
E-mail: llsmith@lanl.gov